NDT Advance Access published July 10, 2012

Nephrol Dial Transplant (2012) 0: 1–9
doi: 10.1093/ndt/gfs272

NDT Nephrology Dialysis Transplantation

Original Article

Evaluation of a pragmatic exercise rehabilitation programme in chronic kidney disease

Sharlene A. Greenwood[1], Herolin Lindup[1], Kevin Taylor[1], Pelagia Koufaki[2], Robert Rush[3], Iain C. Macdougall[1] and Thomas H. Mercer[3]

[1]King's College Hospital, London, UK, [2]Heriot Watt University, Edinburgh, UK and [3]Queen Margaret University, Edinburgh, UK

Correspondence and offprint requests to: Sharlene A. Greenwood; E-mail: sharlene.greenwood@nhs.net

Abstract

Background. Physical activity has the potential to positively impact upon aerobic and functional ability, and the quality of life of all chronic kidney disease (CKD) patients independent of the stage of the disease process. Physical activity is recommended in a number of national CKD guidelines, but its incorporation into routine care has been slow. The translation of research-led physical activity programmes into an established procedure appears to be a particular obstacle. This study included 263 patients, consecutively referred over a 4-year period, to a pragmatic 12-week renal rehabilitation (RR) programme delivered within a National Health Service (NHS).

Methods. One hundred and thirty-one patients were assessed and started the RR programme. Anxiety and depression were measured using the hospital anxiety and depression (HAD) scale. The self-reported level of fitness was measured with the Duke's activity status index (DASI), and exercise capacity was assessed with the incremental shuttle walk test (ISWT), sit-to-stand transfers in 60 s (STS60), timed up and go (TUAG) and stair-climb descent (SCD) tests. All measures were assessed at baseline and at 12 weeks. Attendance and completion of the RR programme were recorded for all patients.

Results. There were significant improvements in exercise capacity and functional ability ranging from 21 to 44%, and significant improvements in anxiety (15%) and depression (29%) in the 77 patients who completed the RR programme. The self-reported level of fitness was found to be significantly associated with completion ($P = 0.01$), with older participants showing a trend towards being more likely to complete ($P = 0.07$). Fifty-four patients, out of the 131 patients who commenced the RR programme, failed to complete 12 or more of the 24 scheduled sessions. Patients requiring haemodialysis (HD) treatment constituted the largest number of drop-outs/non-completers (49%) in the study.

Conclusions. This study demonstrates that a pragmatically constructed, NHS-delivered exercise-based RR can substantially improve both physical function and mental well-being for the wide range of CKD patients who regularly participated (55%). Compliance/adherence data indicate that this type of rehabilitation programme is particularly well received by pre-dialysis (PD) CKD and post-transplantation patients.

Keywords: renal disease; exercise adherence; physical function; rehabilitation; transplantation

Introduction

Chronic kidney disease (CKD) is a long-term condition, which is associated, in many patients, with physical symptoms such as fatigue, muscle weakness and reduced ability to perform activities of daily living. Various types of physical activity have been shown to improve exercise tolerance and optimize physical function in patients with CKD [1, 2]. There have been reported improvements in their independence and ability to perform daily life activities [3]; flexibility, balance and muscle strength [4]; patients' mood, reducing anxiety and depression [5]; cardiovascular risk [6], efficacy of dialysis [7]; the need for antihypertensive medication [8] and weight loss and weight maintenance [9, 10]. These observations have been derived from specifically designed research evaluation studies that have been predominantly conducted on patients who have reached the maintenance dialysis stage (CKD stage 5). Thus far, there have been no reports in the published literature which have evaluated pragmatic, National Health Service (NHS)-delivered, exercise rehabilitation programmes for patients across the entire CKD trajectory. The existing research studies segregate, and exercise, patients with CKD according to the stage of disease, which of course decreases the variability for research purposes, but is somewhat unrealistic if one is aspiring to deliver an exercise programme for all patients with CKD within the financial constraints of a NHS. Consequently, there is likely to be an increased need for exercise rehabilitation programmes that are shown not only to be effective, but can also be realistically implemented at a national level.

Whereas other long-term conditions, such as chronic obstructive pulmonary disease and cardiac disease, offer outpatient exercise-based rehabilitation programmes for their patient groups, this approach has not been used extensively for patients with CKD. Pulmonary and Cardiac Rehabilitation programmes are well established in the UK, and aim not only to improve the general physical ability of patients, but also to gain a better performance from the affected organs, such as the lungs and heart. The renal rehabilitation (RR) programme model described here primarily aimed at improving the physical fitness and well-being of participating patients, but it remains to be established whether such improvements might be associated with the prevention and/or amelioration of the cardiovascular co-morbidities associated with CKD.

The aims of the present study were (i) to ascertain if, and to what extent, the exercise capacity and functional ability could be improved in patients who completed a pragmatically constructed 12-week RR programme, and in light of the heterogeneous nature of the disease status of the patients participating in the programme, and (ii) to conduct an additional analysis that documented and explored potential participant characteristics that might be associated with adherence to, and/or dropout from, the programme. The overall objective was to explore whether a pragmatic, supervised outpatient, exercise programme could be feasibly implemented as an effective approach to improving aspects of activities of daily living-related functional capacity in a group of patients spanning the entire CKD trajectory.

Methods

Study design

We implemented an exploratory, uncontrolled cohort study over a period of 12 weeks. We aimed to evaluate the effectiveness, practicality and feasibility of a pragmatic exercise programme, appropriate for delivery in a UK NHS trust, for all patients with CKD. The study was approved by the King's College Hospital Research Ethics Committee.

Patients

Adult CKD patients (over the age of 18) at various stages of CKD, predialysis (PD) (CKD stages 3–4), receiving maintenance haemodialysis (HD) (CKD stage 5) and post-transplants (TX) (CKD stage 5), under the care of the renal unit at King's College Hospital, were considered eligible for the RR programme. Patients were actively referred to the programme by a member of the renal team. New kidney transplant recipients were eligible for the programme after a 6-week recovery period and clearance from the medical team. The existing kidney transplant recipients under the care of the renal unit were also eligible for the programme. The exclusion criteria included unstable angina, acute left ventricular failure, a serious cardiac event in the preceding 6 weeks, uncontrolled cardiac arrhythmias and uncontrolled hypertension. Demographic data including age, sex and stage of kidney disease were collected.

Renal rehabilitation programme structure

Recent UK developments in the therapeutic management of patients with CKD within the NHS have resulted in the development and pilot implementation of a RR programme. In collaboration with the Modernization Initiative in Kidney Disease, a local NHS Trust improvement initiative, a pragmatic, routine, service-delivered RR programme [11] was piloted and established within the UK NHS Foundation Trust.

Table 1. Outline of the supervised and home-based exercise prescriptions, and the educational component of the programme

Time spent in activity	Activity	Exercise intensity
10 min	Warm-up progressing from isolated mobilizing to gross mobilizing exercises.	RPE 11
40 min	25% aerobic exercise including treadmill and static cycling.	RPE 13–15
	25% strength conditioning including closed and open-chain body weight resistance and free weights.	Based on 10 repetition maximum score
	25% muscular endurance	
	25% balance training	
10 min	Cool-down consisting of stretching and balancing exercises	RPE 11
30 min/×1 week (supervised sessions)	Education—the role of exercise; personalizing exercise plans; goal setting; long-term exercise planning; overcoming barriers and relapse prevention. Tea/ coffee.	

The programme, modelled on conventional cardio-pulmonary rehabilitation [12–14], aims to deliver an individualized rehabilitation programme incorporating combined exercise training and self-management education. It is a comprehensive intervention designed to improve activities of daily living-related functional capacity, reduce symptoms of fatigue and increase motivation, confidence, functional status and health-related quality of life in patients with CKD. A team consisting of a lead renal physiotherapist (band 8A), a specialist physiotherapist (band 6/7) and a technical instructor (band 4) delivered the exercise, education and self-management advice for the programme. The patients were required to attend twice-weekly supervised outpatient exercise and the education sessions, and to perform once-weekly home-based exercise for a period of 12 weeks. Data were collected at the first visit (baseline) and at 12 weeks. An indicative outline of the supervised and home-based exercise prescriptions, and the educational component of the programme is presented in Table 1.

The exercise prescription was modified to suit patients with differing functional abilities and needs, by introducing new pieces of equipment or varying the number of sets/time. Exercise intensity was progressed if patients consistently reported a rating of perceived exertion (RPE) one unit or more below the desired level for three consecutive sessions. Resistance training prescription started from 1 set ×8–10 repetitions and progressively increased to 3 sets ×8–10 repetitions. When patients achieved this level, the resistance was increased. Home-based exercise was performed once-weekly with a generic exercise programme, which included the same components as the supervised programme. We addressed barriers to lifestyle change through the use of cognitive behavioural therapy mechanisms such as goal-setting and problem-solving exercises, as well as a continuous exercise diary for each supervised and home-based exercise session. Patients were encouraged to record the duration, number of sets and RPE level for each exercise. The home-based exercise diaries were examined each week. The exercise programme was adjusted as required, and any problems (such as muscle aching/pain) were addressed by adding in specific stretching exercises; encouragement for continued participation was also given. Following the 12-week intervention, patients were referred on to local gym programmes, walking groups or were advised to continue the exercises described in the home-based exercise diary.

The joint American College of Chest Physicians (ACCP) and American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR) evidence-based clinical practice guidelines for pulmonary rehabilitation [12, 13] recommend that education be an integral part of pulmonary rehabilitation. The goal of patient education within this RR programme was to improve clinical outcomes by teaching self-management skills, thus increasing self-efficacy and adherence. Patients were also offered refreshments during the education component, and the opportunity to remain and talk to each other after the education element of the programme. The benefit of peer support and the opportunity to exercise with similar individuals were consistently highlighted as beneficial to patients throughout the study period.

Outcomes and assessments

Due to the heterogeneous nature of the patient group, a general functional capacity/status outcome measure was chosen to assess goals. This primary outcome was the self-reported Duke's activity status index (DASI), a weighted, 12-item closed-response questionnaire measuring the functional ability, which spans the spectrum of ability to complete activities of daily living to sporting activities [12, 13]. The secondary objective outcomes included four measures of functional capacity, including the incremental shuttle walk (ISWT), the timed up and go 3 m (TUAG), the sit-to-stand in 60 s (STS60) and the stair-climb descent (SCD) tests. The ISWT is a test developed to simulate a cardiopulmonary exercise test using a field walking test. The test participant walks 10 m between two cones in time to a set of auditory beeps, on a CD, which increase in frequency [14]. The TUAG is a composite test of agility which measures the time taken for the test participant to stand from a seated position, walk around a cone set at a 3 m distance and return to a seated position [15]. The STS60 is a measure of the number of sit-to-stand transfers achieved in 60 s and a good proxy for muscular endurance conditioning [16]. The SCD records the time taken for the test participant to climb and descend 18 steps. The Borg's RPE, a scale ranging from 6 to 20 [17], was used to monitor the perceived level of effort for each physical test. The emotional/psychological attributes were assessed with the hospital anxiety and depression (HAD) score, a questionnaire with a total of 14 questions—seven relating to anxiety and seven to depression [18]. The body mass index (BMI) was also assessed according to the formula weight (kg)/height (m^2).

All outcome assessments, including questionnaires, were recorded at baseline, and again at 12 weeks. All patients were assessed prior to the first class, and 12-week assessments were performed prior to the last class in that week. Attendance at each of the RR programme sessions were recorded for each patient. Patients were classified as completers if they attended 12 or more of the 24 supervised sessions that constitute a full RR programme, and had baseline and 12-week data.

Statistical analysis

Standard descriptive statistics, consisting of mean (SD), were used to characterize the groups of patients. Mean baseline age, weight, BMI, HAD and functional capacity test scores were calculated for the entire study population and also by treatment sub-group (PD, HD, TX). Independent *t*-tests were performed for the sub-groups classified as completers or non-completers (pooled overall and by treatment sub-group). To evaluate the overall effect of the RR programme at 12 weeks, Student's paired *t*-tests (or appropriate non-parametric equivalents) were used to examine differences in weight, exercise capacity and functional ability scores for participants who completed >12 sessions in the RR programme (completers). One-way analysis of variance was employed at baseline to explore for differences between treatment sub-groups.

Results

Figure 1 describes the flow of patients throughout the RR programme. Table 2 summarizes the baseline characteristics of the patients referred to the RR programme. Bonferroni-adjusted *post-hoc* contrasts showed that the groups were similar with respect to baseline exercise and psychological outcomes, but the TX group differed from both the PD and HD groups, $P < 0.001$ for each, with the TX group having patients of a younger age. The TX group differed from the PD group, with the TX group being smaller in height ($P = 0.046$). The PD group differed from both the TX and HD groups, $P < 0.001$ in each case, with the PD group being heavier and having higher BMI scores. The TX group was significantly different ($P = 0.002$) from the HD group, having lower BMI scores.

The pre-post intervention results are presented in Table 3. Significant differences were found overall between pre and post for all assessments showing improved outcomes at post time point with TUAG, SCD, HAD-A and HAD-D scores decreasing and ISWT, STS60 and DASI increasing. Within the PD sub-group similar changes were observed except for HAD-A, which did not decrease significantly. Within the HD modality similar changes were observed as for overall. Within the TX modality a similar pattern of change was observed with the exceptions of STS60, HAD-A and HAD-D not achieving statistical significance. Table 3 displays the significant percentage improvement in exercise, functional and psychological outcome measures, ISWT (44%), TUAG (25%), STS60 (21%), SCD (28%), DASI (35%), HAD-A (16%) and HAD-D (28%) post-intervention.

Table 4 presents a baseline comparison of the exercise, functional and psychological outcomes for completer and non-completer sub-groups referred to, and assessed, in the RR programme. Overall, there was a difference at baseline between the completers and non-completers on the DASI score, with the non-completers having lower/poorer

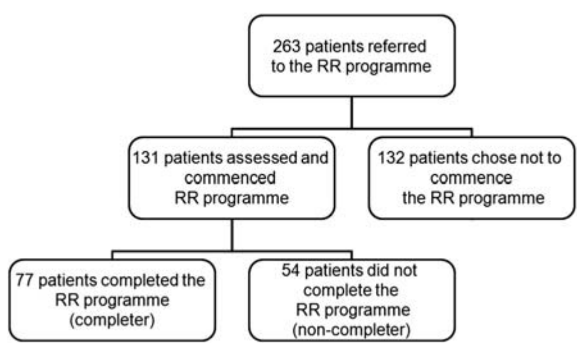

Fig. 1. Flow diagram describing patient participation in the RR programme.

Table 2. Baseline characteristics of all patients referred to the RR programme

Overall	PD ($n = 80$) Mean (SD)	HD ($n = 128$) Mean (SD)	TX ($n = 55$) Mean (SD)	Total ($n = 263$) Mean (SD)	F $_{(df1,df2)}$, P
Age (years)	58.73 (13.46)	56.58 (12.24)	50.75 (13.41)	56.01 (13.14)	[a]6.507 (2.260), 0.002
Sex (F%/M%)	52.5/47.5	41.4/58.6	54.5/45.5	47.5/52.5	3.803 (2),
Height (m)	1.69 (0.1)	1.66 (0.08)	1.64 (0.1)	1.67 (0.09)	[b]3.398 (2.164), 0.036
Weight (kg)	99.38 (21.76)	82.97 (17.53)	75.5 (18.61)	86.49 (21.25)	[c]27.833 (2.237), <0.001
BMI	34.84 (5.71)	30.5 (5.65)	26.51 (5.76)	31.31 (6.4)	[d]24.892 (2.178), <0.001
ISWT (m)	231.9 (148.7)	247.7 (137.1)	293.5 (141.7)	252.5 (143.5)	2.526 (2.187), 0.083
TUAG (s)	10.1 (3.4)	10.2 (11.0)	8.6 (3.4)	9.8 (7.6)	0.715 (2.189), 0.49
STS60 (reps)	19.3 (8.0)	19.3 (7.1)	21.7 (6.4)	19.8 (7.3)	1.759 (2.189), 0.175
SCD (s)	37.5 (33.2)	29.9 (21.0)	27.1 (13.6)	31.9 (25.0)	2.712 (2.180), 0.069
DASI (/60max)	26.0 (13.5)	23.8 (10.6)	25.9 (10.8)	25.1 (11.7)	0.757 (2.185), 0.47
$HAD_{anxiety}$	6.9 (4.4)	7.9 (4.3)	7.8 (4.7)	7.5 (4.4)	0.997 (2.184), 0.371
$HAD_{depression}$	6.4 (3.4)	6.9 (3.1)	7.0 (3.95)	6.7 (3.4)	0.516 (2.184), 0.598

Bonferroni-adjusted *post-hoc* contrasts showed that;

[a]Age; the TX group differed from both PD and HD, $P < 0.001$ for each, with TX having patients of younger age groups.

[b]Height; the TX group differed from PD, being smaller, $P = 0.046$.

[c]Weight; the PD group differed from both the TX and HD groups, $P < 0.001$ in each case, with the PD group being heavier. When adjusted the TX group was no longer significantly different from the HD group, $P = 0.060$.

[d]BMI; the PD group differed from both the TX and HD groups, $P < 0.001$ in each case, with PD group having larger BMI scores. The TX group was significantly different from the HD group, $P = 0.002$, having lower BMI scores.

scores. Within the HD group, there was a difference between the completers and non-completers on the ISWT with the non-completers having lower/poorer scores Within the PD and TX treatment sub-groups there were no differences between the completers and non-completers across the outcomes. Exploratory *post-hoc* analysis of the underlying clinical characteristics of the completer and non-completer groups indicated that no significant differences existed for haemoglobin [11.77 (1.67) versus 11.53 (1.70) g dL^{-1}; $t = 0.782$ (119), $P = 0.436$] or serum potassium concentrations [4.83 (0.72) versus 5.07 (0.64) mmol L^{-1}; $t = -1.904$ (119), $P = -0.059$]. However, further analysis by treatment mode (PD, HD and TX) indicated that a significant difference was observed in haemoglobin concentration for the TX group [12.28 (1.5) versus 11.3 (0.58) g dL^{-1}; $t = 2.308$, $P = 0.032$].

Discussion

Analysis of participant characteristics at baseline entry into the RR programme (Table 2) revealed a subgroup of transplanted patients who were significantly younger than the PD group, and significantly lighter than both the PD and HD groups. This finding is understandable when one takes into account the stringent criteria that patients must meet to be considered for kidney transplantation. However, it was noteworthy that no other significant differences were observed between these clinically diverse treatment sub-groups (PD, HD and TX) of CKD patients in terms of either objectively determined or self-reported functional capacity/status. To some extent this is somewhat counterintuitive as one might plausibly speculate that PD patients, having not yet progressed to the levels of pathophysiological derangement precipitated by and associated with the need for maintenance dialysis, should perhaps exhibit higher levels of activity of daily living-related functional capacity in comparison with CKD 5 patients [19]. Similarly, one might expect that transplanted patients, with the associated reversal of uraemic symptoms, would also possibly be characterized by an improved capacity for activities of daily living in comparison with their CKD 5 maintenance dialysis counterparts [20]. Our observations of a generalized standard of physical function (dysfunction) amongst the three treatment sub-groups regardless of their location in the disease trajectory would appear to underscore the potential need for exercise rehabilitation in optimizing the management of all CKD patients.

This study demonstrated that statistically significant improvements in exercise capacity (44%) and functional ability (21–35%) were achievable by those patients who ‘completed’ the supervised RR programme (see Table 3). There was however a considerable amount of inter-patient variability which is to be expected with such a heterogeneous participant group. The results from this RR programme are comparable with exercise and functional capacity outcome improvements reported following pulmonary [13] and cardiac [21] rehabilitation programmes which are conducted in a similar way, and are also consistent with a number of studies that evaluated the effect of training programmes in dialysis patients [1, 2, 22]. These programmes showed significant improvements in aerobic capacity ranging from 21% to 43% in dialysis patients (CKD stage 5) lasting from 3 to 6 months. The study by Konstantinidou *et al.* [22] included a supervised outpatient programme for dialysis patients and demonstrated a 43% improvement in aerobic capacity which is comparable with the findings of this study.

The increased perceived functional ability, as shown by the significant increase in the DASI score of 35% (see Table 3), extrapolates to patients being able to complete activities of daily living with greater ease. There were also significant improvements in a range of functional outcome measures (21–35%) at 12 weeks when compared with baseline (see Table 4). These results are consistent with previous reports from two combined

Table 3. Pre-post intervention results for the those patients 'completing' the RR programme (Completers group)

	PD ($n = 32$)		HD ($n = 29$)		TX ($n = 16$)		Total ($n = 77$)		
	Mean (SD)	t (df), P	Mean (SD)	t (df) P	Mean (SD)	t (df), P	Mean (SD)	t (df), P	%Improvement
ISWT (m)									
Pre	200.6 (113.9)		253.9 (121.6)		289.4 (138.4)		239.1 (125.5)		44
Post	321.6 (195.5)	−4.972 (31), <0.001[b]	350.7 (182.8)	−4.2 (28), <0.001[c]	377.5 (177.9)	−3.015 (15), 0.009[d]	344.2 (186.1)	−7.221 (76), <0.001[a]	
TUAG (s)									
Pre	10.5 (3.63)		8.6 (3.25)		8.1 (2.83)		9.3 (3.45)		25
Post	7.4 (2.2)	6.15 (31), <0.001[b]	6.7 (1.5)	4.462 (28), <0.001[c]	6.9 (1.6)	2.887 (15), 0.011[d]	7.0 (1.8)	7.867 (76), <0.001[a]	
STS60 (reps)									
Pre	19.1 (8.0)		20.5 (6.6)		22.3 (6.2)		20.3 (7.1)		21
Post	23.8 (7.3)	−5.68 (30), <0.001[b]	25.64 (8.3)	−4.679 (27), <0.001[c]	24 (6.9)	−1.455 (15), 0.166	24.52 (7.6)	−7.004 (74), <0.001[a]	
SCD (s)									
Pre	38.87 (28.52)		30.21 (19.68)		25.75 (9.47)		32.72 (22.62)		28
Post	26.5 (15.5)	4.101 (29), <0.001[b]	22.3 (9.5)	3.12 (28), 0.004[c]	21.0 (6.9)	3.022 (15), 0.009[d]	23.7 (12.0)	5.6 (74), <0.001[a]	
DASI (/60 max)									
Pre	25.9 (11.8)		23.0 (9.1)		26.1 (11.8)		24.8 (10.8)		35
Post	34.3 (13.5)	−5.338 (31), <0.001[b]	32.8 (13.1)	−4.43 (28), <0.001[c]	33.8 (12.9)	−3.418 (15), 0.004[d]	33.6 (13.0)	−7.667 (76), <0.001[a]	
HAD-anxiety									
Pre	6.8 (4.5)		7.2 (3.9)		7.4 (4.8)		7.1 (4.3)		16
Post	5.9 (4.1)	1.365 (31), 0.182	5.48 (4.09)	2.849 (28), 0.008[c]	6.94 (4.48)	0.685 (15), 0.504	5.95 (4.15)	2.909 (76), <0.005[a]	
HAD-depression									
Pre	6.4 (3.7)		7.3 (3.1)		7.5 (3.9)		7.0 (3.5)		29
Post	4.34 (3.34)	4.442 (31), <0.001[b]	5.07 (3.5)	4.438 (28), <0.001[c]	6.19 (3.87)	1.412 (15), 0.178	5 (3.54)	5.973 (76), <0.001[a]	

[a]Significant differences were found overall between pre and post for all assessments showing improved outcomes at post time point with TUAG, SCD, HAD-A and HAD-D scores decreasing and ISWT, STS60 and DASI increasing.
[b]Within the PD sub-group similar changes were observed except for HAD-A, which did not decrease significantly.
[c]Within the HD modality similar changes were observed as for overall.
[d]Within the TX modality a similar pattern of change was observed with the exceptions of STS60, HAD anxiety and HAD depression not achieving statistical significance.

Table 4. Comparison of baseline data for completer and non-completer sub-groups

	PD			HD			TX			Overall		
	N	Mean (SD)	*t* (df), *P*	*N*	Mean (SD)	*t* (df), *P*	*N*	Mean (SD)	*t* (df), *P*	*N*	Mean (SD)	*t* (df), *P*
Age (years)												
Completers	32	59.3 (12.2)		29	60.7 (12.1)		16	55.3 (13.3)		77	59.0 (12.4)	
Non-completers	14	56.8 (13.8)	0.62 (44), 0.539	28	57.2 (10.9)	1.139 (55), 0.26	12	47.5 (15.1)	1.454 (26), 0.158	54	54.9 (13.1)	1.802 (129), 0.074
Height (m)												
Completers	32	1.68 (0.11)		29	1.65 (0.07)		16	1.64 (0.13)		77	1.66 (0.10)	
Non-completers	14	1.67 (0.11)	0.229 (44), 0.82	28	1.68 (0.08)	−0.974 (55), 0.337	12	1.64 (0.04)	0.087 (26), 0.932	54	1.67 (0.09)	−0.311 (129), 0.756
Weight (kg)												
Completers	32	95.5 (22.2)		29	80.4 (16.3)		16	83.1 (18.8)		77	87.2 (20.4)	
Non-completers	14	96.7 (20.1)	−0.16 (44), 0.874	28	87.3 (18.03)	−1.475 (55), 0.146	12	69.1 (19.3)	1.929 (26), 0.065	54	85.4 (21.0)	0.472 (129), 0.637
BMI												
Completers	32	33.9 (6.2)		29	29.9 (5.6)		16	27.7 (5.4)		77	31.4 (6.3)	
Non-completers	14	33.6 (3.4)	0.197 (44), 0.845	28	31.6 (6.3)	−0.917 (55), 0.365	12	26.4 (8.7)	0.312 (26), 0.764	54	31.3 (6.4)	0.041 (129), 0.967
ISWT[b] (m)												
Completers	32	200.6 (113.8)		29	253.9 (121.6)		16	289.4 (138.4)		77	239.1 (125.5)	
Non-completers	11	210.9 (142.4)	−0.242 (41), 0.81	27	188.6 (105.9)	2.136 (54), 0.037[b]	12	235 (133.7)	1.043 (26), 0.306	50	204.6 (120.4)	1.538 (125), 0.127
TUAG (s)												
Completers	32	10.5 (3.6)		29	8.6 (3.3)		16	8.1 (2.8)		77	9.3 (3.5)	
Non-completers	12	10.2 (3.4)	0.181 (42), 0.857	27	10.1 (3.2)	−1.808 (54), 0.076	12	10.4 (5.0)	−1.556 (26), 0.132	51	10.2 (3.6)	−1.501 (126), 0.136
STS60 (reps)												
Completers	32	19.2 (7.9)		29	20.6 (6.5)		16	22.3 (6.2)		77	20.3 (7.1)	
Non-completers	12	18.2 (6.7)	0.387 (42), 0.701	27	17.7 (6.7)	1.61 (54), 0.113	12	19.9 (8.1)	0.867 (26), 0.394	51	18.3 (6.9)	1.573 (126), 0.118
SCD (s)												
Completer	30	38.9 (28.5)		29	30.2 (19.7)		16	25.8 (9.5)		75	32.7 (22.6)	
Non-completers	11	29.2 (18.8)	1.042 (39), 0.304	24	30.7 (13.0)	−0.114 (51), 0.91	12	32.3 (19.4)	−1.185 (26), 0.247	47	30.8 (15.9)	0.513 (120), 0.609
DASI[a] (/60 max)												
Completers	32	25.9 (11.8)		29	23.0 (9.2)		16	26.1 (11.8)		77	24.8 (10.8)	
Non-completers	13	19.5 (11.8)	1.644 (43), 0.107	27	20.6 (8.9)	0.99 (54), 0.326	11	19.7 (8.4)	1.532 (25), 0.138	51	20.1 (9.5)	2.522 (126), 0.013[a]
HAD anxiety												
Completers	32	6.8 (4.5)		29	7.2 (3.9)		16	7.4 (4.8)		77	7.1 (4.3)	
Non-completers	13	6.6 (4.6)	0.132 (43), 0.895	27	9.0 (5.2)	−1.415 (54), 0.163	12	8.8 (4.6)	−0.778 (26), 0.443	52	8.4 (4.9)	−1.521 (127), 0.131
HAD depression												
Completers	32	6.4 (3.7)		29	7.3 (3.1)		16	7.5 (3.9)		77	7.0 (3.5)	
Non-completers	13	6.9 (3.4)	−0.371 (43), 0.713	27	6.6 (2.9)	0.903 (54), 0.371	12	7.3 (4.1)	0.164 (26), 0.871	52	6.8 (3.3)	0.282 (127), 0.778

[a] Overall there was a difference at baseline between the completers and non-completers on the DASI, with the non-completers having lower/poorer scores.
[b] Within the HD group there was a difference between the completers and non-completers on ISWT with the non-completers having lower/poorer scores. Within the PD and TX treatment sub-groups there were no differences between completers and non completers across the outcomes.

aerobic and strengthening programmes conducted in HD patients [23, 24]. An adequate level of physical capacity for activities of daily living is likely to improve independence, and possibly employment potential, of patients with CKD (a recent survey shows that <10% of the local HD population are currently in full or part time paid employment). It may also improve the functional status of those patients who would like to be considered for future renal transplantation. Indeed, comprehensive cardiac rehabilitation has been shown to aid psychological function, social recovery, return to work and biological risk factors for cardiovascular disease [21].

Psychological distress appears to be a fairly common disorder in patients with CKD and may be a result of the increased morbidity and mortality associated with this progressive disease. Participants who completed the RR programme demonstrated improvements in the mean level of anxiety (16%) and depression (28%), as measured with the HAD score (see Table 3). This finding is consistent with two previous studies of HD patients [25, 26] that demonstrated improvements in anxiety and mental health scores using the SF-36 Quality of Life Scale, and supports the observations of Kouidi *et al*. [27] who reported a significant improvement in the HAD score of 23% in patients who completed their 1-year HD exercise programme. RR incorporating a substantial exercise programme component may therefore be utilized, not only for improvements in physical function, but also to aid psychological recovery.

To better contextualize our observations regarding the potential effectiveness of this type of RR programme we also attempted to characterize some of the factors which may affect patient compliance. To do this we subdivided our sample into groups of completers (those attending and successfully completing at least 12 of 24 supervised exercise sessions) and non-completers (those failing to attend at least 12 supervised exercise sessions) and compared these groups with their baseline characteristics (see Table 4). Out of all the exercise capacity and functional measures, only a higher self-reported level of fitness, as evaluated by the DASI, was shown to be significantly different between these groups in their compliance with the study programme ($P = 0.013$). The DASI outcome measure may therefore have potential as a means of screening and identifying patients who might have difficulty in adhering to a programme of RR. In particular, this may highlight those low-functioning patients who will require an extensively supported exercise prescription (possibly including pre-rehabilitation interventions simply to develop exercise self-confidence) with carefully tailored applied motivational support strategies. The mean age difference between both the groups, although not significant, exhibited a trend ($P = 0.07$) in favour of the completer group having older patients (mean 59 years), compared with the non-completer group (mean 55 years) (see Table 4). The older patients who attend this type of week day classes are less likely to be involved in work-related activities. This may have a positive effect on attendance rates. This challenges the research on cardiac rehabilitation which suggests that younger age is a predictor of adherence [21], but that may be a reflection of the age of the patients participating in cardiac rehabilitation and the time of day that classes are offered.

The high number of dropouts/non-completers in this study (54 of the 131 patients who commenced the programme), prompted additional analyses of the characteristics of the whole group according to treatment modality (PD, HD and TX). A between-group comparison (see Table 4) established that within the PD and TX treatment sub-groups, there were no differences between the completers and non-completers across the outcomes. Within the HD group, there was a significant difference between the completers and non-completers on the ISWT, with the non-completers having lower/poorer scores. The HD group was also found to constitute the largest proportion (49%) of the non-completer group. Patients receiving HD already require thrice-weekly hospital appointments, and often suffer from muscle weakness and fatigue [28]. They are therefore less likely to complete a 12-week RR programme on non-dialysis days. Konstantinidou *et al*. [22] reported a larger improvement in peak oxygen consumption for patients randomized to their supervised outpatient programme (43%), compared with home-based exercise (37%) and exercise-on-dialysis (33%), but also reported a larger dropout rate (24% versus 17% versus 17%) in this group. Similarly, Kouidi *et al*. [29] compared a supervised training programme for HD patients on non-dialysis days with exercise during dialysis, and demonstrated better improvements in peak oxygen consumption (47% versus 31%) in the supervised programme, but also a higher drop out rate (33% versus 21%). It must be acknowledged that although this reported RR programme is a commendable use of finite resources, there is a possible tension with exercising HD patients on non-dialysis days. It is perhaps slightly unrealistic to expect patients receiving hospital-delivered HD therapy to attend additional hospital-based exercise classes on non-dialysis days. The ISWT scores were also significantly lower for the non-completers in the HD group. The optimal delivery of physical activity for HD patients, if resources allow, may be exercise during dialysis sessions, while an outpatient RR programme may be more appropriate for PD and kidney transplant patients.

This study sought to examine whether a pragmatic outpatient RR programme combining exercise, education and self-management advice could impact on exercise capacity and functional ability in patients with CKD. To our knowledge, no studies have evaluated these exercise and functional ability parameters as part of an outpatient physiotherapy-led programme in patients at various stages of the CKD trajectory. Although it is recognized that the heterogeneity and varying characteristics of the group may have influenced results, it is important in the current financial climate to be able to offer a generic exercise programme to which health professionals can refer all patients with CKD.

Limitations

There are a number of limitations in this study. It is an uncontrolled study design, and is reflective of only one RR programme. The lack of a controlled design inherently prevents the comparison of changes in exercise capacity, functional ability and BMI in those patients that chose to participate in the RR programme with those who do not enrol in this type of programme, and therefore there is a selection bias in favour of those patients who are motivated enough already to enrol in a 12-week programme. The results from the RR programme do however suggest that this multi-disciplinary programme can achieve improvements in exercise capacity and functional ability in CKD patients, potentially giving them the opportunity of returning to work and increased physical functioning, with the associated benefits of this. The self-reported level of fitness and patient age may predict who is most likely to complete this type of programme.

Conclusion

In conclusion, we believe that this is the first report that highlights changes in exercise tolerance and functional ability in CKD patients using a physiotherapy-led, 12-week, RR programme. It demonstrates an exercise model that is both practicable and relatively easily implemented for patients with CKD in a NHS trust.

It also demonstrates that such an approach can be effective for those patients who regularly participate. In this regard, consideration must be given to the delivery of exercise-on-dialysis programmes to better enhance the participation and thus potential benefits to patients undergoing maintenance HD therapy. Further evaluation trials are recommended to determine whether the beneficial effects demonstrated in this RR programme can also impact on the high cardiovascular risk inherent in this patient population.

Conflict of interest statement. The results presented in this paper have not been published previously in whole or part.

Acknowledgements. The authors would like to thank the rest of the RR team for their input—Chloe Apps, Sarah Cox, Claire Coombes, Lynda Haggis, Denise Grant, Rebecca Hopwood, Rachel Garrod and Tony DeBoeck.

Funding. The programme was set up and conducted with funding from the Modernization Initiative in Kidney Disease. The manuscript was written entirely by the authors, with no input from a ghostwriter, the Modernization Initiative in Kidney Disease or a pharmaceutical company.

References

1. Storer TW, Casaburi R, Sawelson S *et al*. Endurance exercise training during haemodialysis improves strength, power, fatigability and physical performance in maintenance haemodialysis patients. *Nephrol Dial Transplant* 2005; 20: 1429–1437.
2. Cheema BSB, Fiatarone Singh MA. Exercise training in patients receiving maintenance hemodialysis: a systematic review of clinical trials. *Am J Nephrol* 2005; 25: 352–364.
3. Gutman RA, Stead WW, Robinson RR. Physical activity and employment status of patients on maintenance dialysis. *N Engl J Med* 1981; 304: 309–313.
4. Koufaki P, Mercer TH, Naish PF. Effects of exercise training on aerobic and functional capacity of end-stage renal disease patients. *Clin Physiol Funct Imaging* 2002; 22: 115–124.
5. Kouidi E, Iacovides A, Iordanidis P. Exercise renal rehabilitation program: psychosocial effects. *Nephron* 1997; 77: 152–158.
6. Goldberg AP, Geltman EM, Gavin JR, III. Exercise training reduces coronary risk and effectively rehabilitates hemodialysis patients. *Nephron* 1986; 42: 311–316.
7. Kong CH, Tattersall JE, Greenwood RN *et al*. The effect of exercise during haemodialysis on solute removal. *Nephrol Dial Transplant* 1999; 14: 2927–2931.
8. Miller BW, Cress CL, Johnson ME *et al*. Exercise during hemodialysis decreases the use of antihypertensive medications. *Am J Kidney Dis* 2002; 39: 828–833.
9. Cook SA, MacLaughlin H, Macdougall IC. A structured weight management programme can achieve improved functional ability and significant weight loss in obese patients with chronic kidney disease. *Nephrol Dial Transplant* 2008; 23: 263–268.
10. MacLaughlin HL, Cook SA, Kariyawasam D *et al*. Nonrandomized trial of weight loss with orlistat, nutrition education, diet, and exercise in obese patients with CKD: 2-year follow up. *Am J Kidney Dis* 2010; 55: 69–76.
11. Greenwood S. The role of the physiotherapist in the renal unit. *J Renal Nurs* 2010; 2: 292–295.
12. American College of Chest Physicians, American Association of Cardiovascular and Pulmonary Rehabilitation. Pulmonary rehabilitation: joint ACCP/AACVPR evidence-based guidelines; ACCP/AACVPR pulmonary rehabilitation guidelines panel. Bauldoff G., Carlin B. and Casaburi, R. Pulmonary rehabilitation* joint ACCP/AACVPR evidence-based clinical practice guidelines. *Chest* 2007; 131: 4S–42S.
13. Hlatky MA, Boineau RE, Higginbotham MB *et al*. A brief self-administered questionnaire to determine functional capacity (the Duke activity status index). *Am J Cardiol* 1989; 64: 651–654.
14. Tobin D, Thow MK. The 10 m shuttle walk test with Holter monitoring: an objective outcome measure for cardiac rehabilitation. *Coron Health Care* 1999; 3: 3–17.
15. VanSwearingen JM, Brach JS. Making geriatric assessments work: selecting useful measures. *Phys Ther* 2001; 81: 1233–1252.
16. Ritchie C, Trost SG, Brown W *et al*. Reliability and validity of physical tests for adults aged 55 to 70 years. *J Sci Med Sport* 2005; 8: 61–70.
17. Eston R, Thompson M. Use of ratings of perceived exertion for predicting maximal work rate and prescribing exercise intensity in patients taking atenelol. *Br J Sport Med* 1997; 31: 114–119.
18. Zigmond AS, Snaith RP. The hospital anxiety and depression scale. *Acta Psychiatr Scand* 1983; 67: 361–370.
19. McIntyre CW, Selby NM, Sigrist M *et al*. Patients receiving maintenance dialysis have more severe functionally significant skeletal muscle wasting than patients with dialysis-independent chronic kidney disease. *Nephrol Dial Transplant* 2006; 21: 2210–2216.)
20. Nielens H, Lejeune TM, Lalaoui A *et al*. Increase of physical activity level after successful renal transplantation: a 5 year follow-up study. *Nephrol Dial Transplant* 2001; 16: 134–140.
21. Goble AJ, Worcester MU. *Best Practice Guidelines for Cardiac Rehabilitation and Secondary Prevention*. Melbourne: The Heart Research Centre, on behalf of Department of Human Services Victoria, 1999. http://www.health.vic.gov.au/nhpa/downloads/bestpracticecardiacrehab.pdf (accessed Nov 2011).
22. Konstantinidou E, Koukouvou G, Kouidi E *et al*. Exercise training in patients with end-stage renal disease on hemodialysis: comparison of three rehabilitation programs. *J Rehabil Med* 2002; 34: 40–45.
23. DePaul V, Moreland J, Eager T *et al*. The effectiveness of aerobic and muscle strength training in patients receiving hemodialysis and EPO: a randomized controlled trial. *Am J Kidney Dis* 2002; 40: 1219–1229.
24. Van Vilsteren MC, de Greef MH, Huisman RM. The effects of a low-to-moderate intensity pre-conditioning exercise programme linked with exercise counselling for sedentary haemodialysis patients in The Netherlands: results of a randomized clinical trial. *Nephrol Dial Transplant* 2005; 20: 141–146.
25. Oh-Park M, Fast A, Gopal S. Exercise for the dialyzed: aerobic and strength training during hemodialysis. *Am J Phys Med Rehabil* 2002; 81: 814–821.

26. Painter P, Carlson L, Carey S *et al*. Physical functioning and health-related quality-of-life changes with exercise training in hemodialysis patients. *Am J Kidney Dis* 2000; 35: 482–492.
27. Kouidi E, karagiannis V, Grekas D *et al*. Depression, heart rate variability, and exercise training in dialysis patients. *Eur J Cardiovasc Prev Rehabil* 2010; 17: 160–167.
28. Heiwe S, Clyne N, Tollback A *et al*. Effects of regular resistance training on muscle histopathology and morphometry in elderly patients with chronic kidney disease. *Am J Phys Med Rehabil* 2005; 84: 865–874.
29. Kouidi E, Grekas D, Deligannis A *et al*. Outcomes of long-term exercise training in dialysis patients: comparison of two training programs. *Clin Nephrol* 2004; 61: S31–S38.

Received for publication: 21.12.11; Accepted in revised form: 5.5.12